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Cleaner Production (CP), Reduction of Dairy Losses: Case Study from Misr Company for Dairy and Food Mansoura, Egypt

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Abstract

Dairy products are of great importance to the Miser Company for Dairy and Food, Mansoura, Egypt, as they contribute to its development and economic diversification. However, it is necessary to pay attention to the possible environmental impacts caused by the corresponding activities. Thus, the adoption of Cleaner Production (CP) techniques can contribute to improving production processes, as well as providing economic benefits, environmental protection and better working environment.

In other words, it advocates the adoption of clean technologies as an alternative to end-of-pipe treatment technologies. The use of clean technologies in production minimizes waste through process upgrades and improvement, thus reducing reliance upon pollution control equipment. CP includes conserving raw materials and energy; eliminating toxic raw materials; and reducing the quantity and toxicity of all emissions and wastes before they leave a process. For products, the strategy focuses on reducing impacts along the entire life cycle of the product. The discussion also includes various case studies in the Dairy industrial sectors with elaborate cost-benefit analyses. The case studies demonstrate and assess different cleaner production opportunities and implementation techniques.

The objective of CP implementation is to make companies more efficient and less polluting. The project was implemented with the contribution of the Egyptian Environmental Affairs Agency [1,2] through the "Support for Environmental Assessment and Management" program in Miser Company for Dairy and Food, Mansoura, Egypt to reduce the amount of energy, water consumption and reduction of milk losses [3]

This document is a guide to the application of CP in the dairy industry, with a focus on the processing of milk and

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milk products at dairy processing plants. Although dairy processing occurs world wide, the structure of the industry varies from country to country. The major pollutants in the dairy processing Waste Water (WW) are organic materials, suspended solid waste (i.e., coagulated milk, particles of cheese curd, pieces of fruits and nuts), phosphorus, nitrogen, chlorides, heat and acid or alkali content of liquid wastes [4], These pollutants originate from the materials wasted, which are basically milk and milk products through the process, lubricants (primarily soap and silicone based) used in certain handling equipment, sanitary and domestic sewage, non-diary and milk by-products such as whey and sometimes buttermilk [5] and cleaning chemicals. Typical water uses and effluent sources in a dairy factory are given in Figure 1. Even though they are significant sources of environmental contaminants, there are a limited number of studies in the literature [6,7] on CP for dairy food.

This study aims to identify the techniques adopted and opportunities for CP in Miser dairy industry. For this, we carried out a literature review, technical visits and a questionnaire in order to obtain characterization information of the company, CP and environmental management, environmental aspects and impacts related to the production processes. The study revealed that dairy industries are potential polluters, mainly due to their lack of structured environmental programs. Nevertheless, the dairy industry in question was already adopting certain environmental practices and showed interest in learning about others that could contribute to minimizing their impacts and propitiate economic gains. Thus, we successfully identified and presented opportunities for CP.

Introduction

CP is a preventative approach to environmental management that encompasses eco-efficiency, waste minimisation and pollution prevention. CP is a forward-looking, ‘anticipate and prevent’ philosophy. CP does not deny growth; it merely insists that growth be ecologically sustainable [8]. In this context, waste is considered a ‘product’ with negative economic value. Each action to reduce consumption of raw materials and energy, and reduce generation of waste, increases productivity and creates financial benefits. The definition of CP adopted by UNEP [8] is as follows: Cleaner Production is the continuous application of an integrated preventive environmental strategy to processes, product and services to increase overall efficiency, and reduce risks to humans and the environment. For production processes, CP results from one or a combination of conserving raw materials, water and energy; eliminating toxic and dangerous raw materials and reducing the quantity and toxicity of all emissions and wastes at source during the production process.

The dairy industry is beginning to recognise the value of applying CP strategies to improve the sustainability of operations by reducing waste and implementing more efficient processes. UNEP [9] released a major document providing guidelines for manufacturers wishing to apply Cleaner Production strategies. These guidelines categorised CP techniques into the following areas: improved housekeeping, process optimization, new process technology, and new product design.

United Nations Environment Programme [8] defines CP as the continuous, application of an integrated preventive environmental strategy applied to processes, products and services in order to increase efficiency and reduce risks to humans and the environment. For production processes CP includes conserving raw materials and energy, eliminating toxic raw materials, and reducing the quantity and toxicity of all emissions and wastes; for products cleaner production includes the reduction of negative impacts along the life cycle of a product, from raw material extraction to its ultimate disposal; and for services cleaner production is to incorporate environmental concerns into designing and delivering services. Traditional environmental thinking focuses on what to do with wastes and emissions after they have been created (Figure 1).

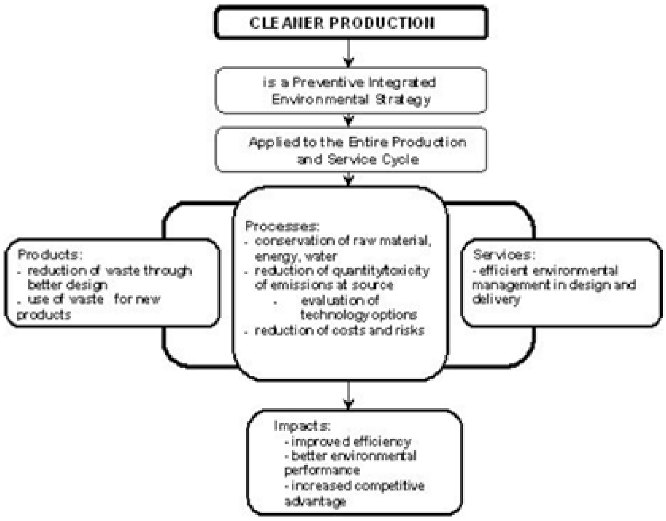

Figure 1: Definition of CP.

Cleaner Production avoids or minimizes waste and pollution even before it is generated! The key difference between pollution control and cleaner production is one of timing. Pollution control is after-the-event, “react and treat” approach; Cleaner Production is a proactive, “anticipate and prevent philosophy”. Prevention is always better than cure. Cleaner Production is not simply a question of changing equipment: “Cleaner Production is a matter of changing attitudes”. The objective of Cleaner Production implementation is to make companies more efficient and less polluting. There are many studies in technical and scientific literature on the application of CP in dairies [10-13].

The CP project was implemented with the contribution of the Egyptian Environmental Affairs Agency [1,2] through the “Support for Environmental Assessment and Management” program in Miser Company for Dairy and Food, Mansoura, Egypt to reduce the amount of energy, water consumption and reduction of milk losses [3]. This document is a guide to the application of CP in the dairy industry, with a focus on the processing of milk and milk products at dairy processing plants.

The Application of CP at Miser Company for Dairy and Food, Egypt, contains background information about the dairy industry and its environmental issues, including quantitative data on rates of resource consumption and waste generation, where available. It presents opportunities for improving the environmental performance of dairy processing plants through the application of CP. Case studies of successful CP opportunities are also presented.

A range of pollution prevention opportunities have been identified and are currently being implemented by Miser Company for Dairy and Food in Mansoura, Egypt. To date, this has involved a total investment of LE 113, 250 and resulting in annual savings of LE 309,250. A summary of how these improvements were identified and the underlying problems solved follows. The main goal of this case study was to assess the application of CP and eco-design as sustainable production tools to improve the environmental efficiency of milk processing industry at Miser Company for Dairy and Food, Mansoura, Egypt, to reduce energy and resources consumption, and at the same time to achieve economic and social benefits (Table 1).

The changes, so-called "Cleaner Production Tools" can be grouped into waste reduction at source; Recycling; and Product modifications.

CP focuses on before-the Event techniques that can be categorized [14] as shown in. as Figure 2:

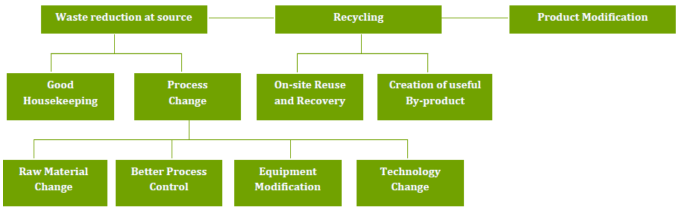

Figure 2: CP techniques. Source: El-Haggar [15].

Based on the work of UNIDO [16], Medeiros et al., [17] and Pimenta & Gouvinhas [18], it is possible to describe a number of benefits of applying the CP techniques:

- Reduce waste disposal cost.
- Reduce raw material cost.
- Reduce Health Safety Environment (HSE) damage cost.
- Improve public relations/image.
- Improve companies' performance.
- Improve the local and international market competitiveness.
- Help comply with environmental protection regulations.

On a broader scale, CP can help alleviate the serious and increasing problems of air and water pollution, ozone depletion, global warming, landscape degradation, solid and liquid wastes, resource depletion, acidification of the natural and built environment, visual pollution, and reduced bio-diversity.

Table 1: Types of CP options.

Types	Options
Housekeeping	Improvements to work practices and proper maintenance can produce significant benefits. These options are typically low cost.
Process optimization	Resource consumption can be reduced by optimizing existing processes. These options are typically low to medium cost.
Raw material substitution	Environmental problems can be avoided by replacing hazardous materials with more environmentally benign materials. These options may require changes to process equipment.
New technology	Adopting new technologies can reduce resource consumption and minimize waste generation through improved operating efficiencies. These options are often highly capital intensive, but payback periods can be quite short.
New product design	Changing product design can result in benefits throughout the life cycle of the product, including reduced use of hazardous substances, reduced waste disposal, reduced energy consumption and more efficient production processes. New product design is a long-term strategy and may require new production equipment and marketing efforts, but paybacks can ultimately be very rewarding.
Source **[4]**	

Investing in Cleaner Production, to prevent pollution and reduce resource consumption is more cost effective than continuing to rely on increasingly expensive 'end-of-pipe' solutions. When CP and pollution control options are carefully evaluated and compared, the CP options are often more cost effective overall. The initial investment for CP options and for installing pollution control technologies may be similar, but the ongoing costs of pollution control will generally be greater than for CP. Furthermore, the CP option will generate savings through reduced costs for raw materials, energy, waste treatment and regulatory compliance (Figure 3).

Figure 3: Some reasons to invest in CP. Source: [4].

The factory

The Mansoura factory, one of the largest producers of dairy products in Egypt, was built in 1965 and has a workforce of around 420. The factory annually processes an average of 7200 tons of milk, producing mainly pasteurized milk, white cheese, blue cheese and mish. Yoghurt, sour cream, ghee and processed cheese are also produced.

CP methodology

Cleaner Production assessment is a useful tool to systematically investigate the existing production and to identify opportunities for improving the production or the products.The cleaner production assessment is carried out in the following six steps: The systematic CP methodology contains 18 tasks under 6 steps as (Table 2) described by [4,19-21]

Table 2: CP Methodology.

Step l. Getting Started
Planning and organization of the CP audit, including the establishment of a project team, baseline data collection and the selection of the audit focus.
Step 2. Analyzing process steps
Evaluations of the unit operations relevant to the selected audit focus in order to quantify waste generation, its costs and its causes.
Step 3. Generating CP Opportunities
Development and preliminary selection of workable CP opportunities.
Step 4. Selecting CP Solutions
Assessing the technical feasibility, financial viability and environmental desirability of preliminary selected CP options in order to select feasible CP solutions.
Step 5. Implementing CP Solutions
Actual implementation of the techno economically viable CP solutions and monitoring of the results achieved by their implementation.
Step 6. Sustaining CP
Tools and techniques for sustaining the implemented CP solutions and elaborating the scope in other areas.
Source: [22]

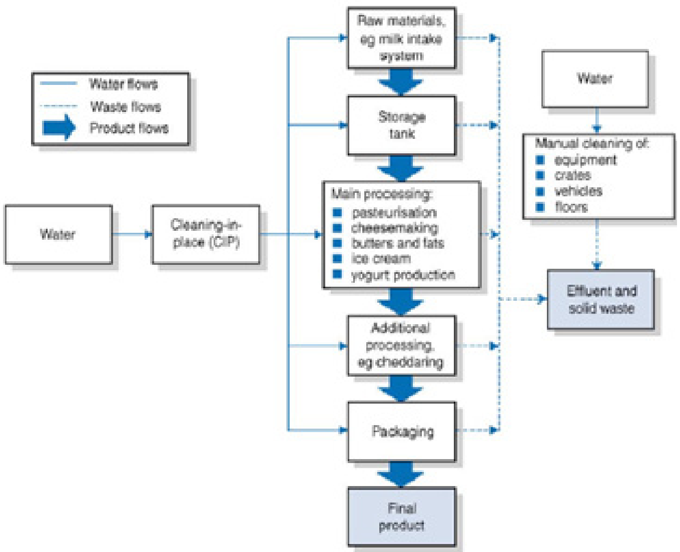

Figure 4: Milk processing.

Figure 5: Butter manufacturing.

Process description

Outlined of main processes

The main process units present in the factory are outlined below:

- Milk receiving, preparation and storage.
- Milk pasteurization.
- White cheese manufacturing.
- Ghee manufacturing.
- Roquefort cheese manufacturing.
- Processed cheese manufacturing.
- Yoghurt and sour cream manufacturing.
- Mish manufacturing.

Figures 4, 5, 6 ,7 and 8 is a flow diagram outlining the basic steps in the production of whole milk, semi-skimmed milk and skimmed milk, cream, butter and buttermilk. In such plants, yogurts and other cultured products may also be produced from whole milk and skimmed milk.

Milk receiving, preparation and storage. Raw milk is delivered from collection centers to the factory's reception area where its tested and graded. If it is a suitable quality, it is then accepted and refrigerated prior to use.

Milk pasteurization. The received milk is pasteurized by being rapidly heated and cooled. It is then either send for packaging or for further processing.

Figure 6: Cream manufacturing.

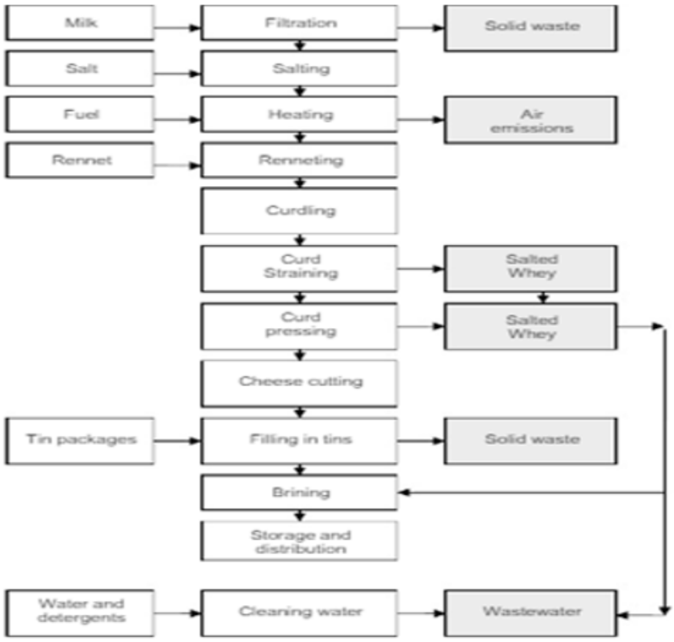

Figure 8: The cheese production process.

Ghee manufacturing: Initially, cream is separated from the raw milk and blended with artificial ghee and salt and then cooked. This mixture is then incubated for a day and then packed. Morta is a generated as a by-product of this process (0.05%), which is also packed and sold.

Roquefort Cheese manufacturing: The pasteurized milk is placed in basins, where it is curded, incubated, and refrigerated, followed by punching. It is stored for one month to allow the blue color to develop and then packed and stored for dispatch. 20% of the milk used in this process is lost as whey.

Processed Cheese manufacturing: Quark and Roquefort cheese are minced and cooked with skimmed milk, whey protein and some additives such as salts and emulsifiers, followed by cooling and packing.

Yoghurt and Sour Cream manufacturing: Milk and fixing agents are mixed to produce yoghurt, which is then automatically packed in small cartons, incubated and refrigerated for dispatch.

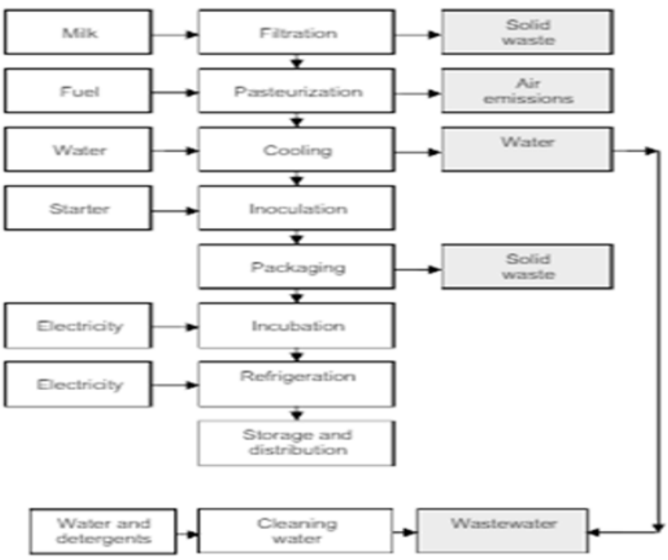

Figure 7: The yogurt production process.

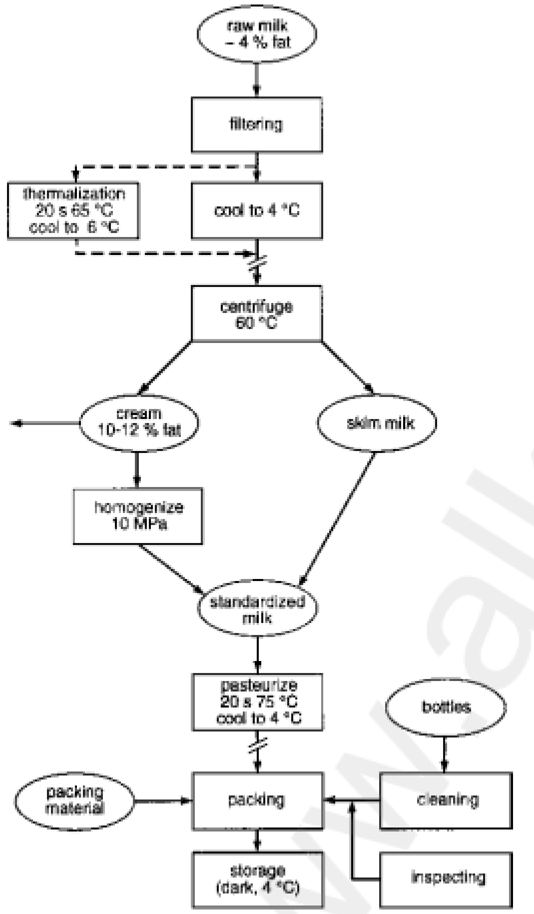

Figure 9: Inputs and outputs from milk receipt and storage vessels.

Mish (Salty Cheese Mix) manufacturing: This isproducedusingdairy products rejects. These are mixed, ground and filtered to separate the solids from the whey. Preservatives are added and the product is packaged.

Milk powder manufacturing: Figure 6 outlines the basic processes for the production of milk powder.

Service units

Factory service units include tin can manufacturing, refrigeration and storage, a boiler station, a quality control laboratory, a warehouse and maintenance workshops.

Environmental impacts

This section briefly describes some of the environmental impacts associated with the primary production of milk and the subsequent processing of dairy products. While it is recognised that the primary production of milk has some significant environmental impacts.

Impacts of primary production

The main environmental issues associated with dairy farming are: the generation of solid manure and manure slurries, which may pollute surface water and groundwater; the use of chemical fertilizers and pesticides in the production of pastures and fodder crops, which may pollute surface water and groundwater; the contamination of milk with pesticides, antibiotics and other chemical residues.

Impacts of dairy processing

the main environmental impacts associated with all dairy processing activities are the high consumption of water, the discharge of effluent with high organic loads and the consumption of energy (Figure 9). Noise, odor and solid wastes may also be concerns for some plants. The "Technical Environmental Guide for the Dairy Products Industry", CETESB [23] present twenty-seven (27) opportunities to obtain CP in dairy products. These opportunities may be observed in Table 3 and cover water consumption, energy consumption, waste, residues and emissions; involving source reduction, recycling/reuse and recovery.

Table 3: CP opportunities in dairy processing.

		Environmental Aspect				
		Water	Energy	Effluents	Waste	Emissions
	Opportunity					
1	Receiving control of raw materials and auxiliary products	*		*	*	
2	Control of stored materials			*	*	
3	Reduction in loss of milk			*	*	
4	Sludge separation in the clarification			*	*	
5	Use of continuous system for milk pasteurization		*			
6	Heat energy recovery		*			
7	Using buttermilk			*		
8	Whey utilization			*		
9	Dry elimination of salt from cheese after salting			*	*	
10	Control and recovery from brine	*			*	
11	Dry cleaning of surfaces	*		*	*	
12	Use of pressurized water for surface cleaning	*		*		
13	Use of foam system for surface cleaning	*		*	*	
14	Use of CIP (clean in place)	*		*		
15	Use of single-use detergents	*		*		
16	Recovery of cleaning products	*		*		
17	Periodic control of the boiler emissions					*
18	Condensate recovery	*				
19	Safe storage and handling of dangerous and hazardous goods			*	*	
20	Minimizing packaging waste				*	
21	Solid waste segregation and resource recovery				*	
22	Wastewater neutralization	*		*		
23	Cogeneration		*			
24	Best practices for reducing water consumption	*		*		
25	Best practices for reducing energy consumption		*			
26	Best practices for the reduction of air gaseous					*
27	Best practices for waste management				*	

Source: **[24]**

Water Consumption

As with most food processing operations, water is used extensively for cleaning and sanitizing plant and equipment to maintain food hygiene standards. Table 4 shows the areas of water consumption within a dairy processing plant, and gives an indication of the extent to which each area contributes to overall water use.

Table 4: Areas of water consumption at dairy processing plants*.

Area of use	Consumption (L/kg product)	Percentage oftotal
Locker room	0.01–1.45	2%
Staff use	0.02–0.44	2%
Boiler	0.03–0.78	2%
Cold storage	0.03–0.78	2%
Receipt area	0.11–0.92	3%
Filling room	0.11–0.41	3%
Crate washer	0.18–0.75	4%
Cooling tower	0.20–1.8	5%
Cleaning	0.32–1.76	8%
Cheese room	0.06–20.89	13%
Utilities	0.56–4.39	16%
Incorporated into products	1.52–9.44	40%
TOTAL	2.21–9.44	100
[25]		

Due to the higher costs of water and effluent disposalthathavenow been imposed in some countries to reflect environmental costs, considerable reduction in water consumption has been achieved over the past few decades in the dairy processing industry. At modern dairy processing plants, a water consumption rate of 1.3–2.5 liters water/kg of milk intake is typical; however, 0.8-1.0 liters water/kg of milk intake is possible [26]. To achieve such low consumption requires not only advanced equipment, but also very good housekeeping and awareness among both employees and management. The Water Consumption at dairy processing Miser Company uses about 37,080 m^3/year of water from the Mansoura City potable water supply (Table 5).

Effluent discharge

Effluent discharges are the main causes of environmental impacts in the dairy industry. The constituents present in dairy effluent are milk fat, protein, lactose and lactic acid, as well as sodium, potassium, calcium and chloride. Milk loss to the effluent stream can amount to 0.5-2.5% of the incoming milk, but can be as high as 3-4%. Table 6 provides a list of the sources of milk losses to the effluent stream at dairy processing Miser Company.

The whey is a by-product from the manufacture of cheese, wherein 80 to 90% of milk that enter the process are converted into the whey. Therefore, due to its high nutrient value and organic load, it should not be mixed with the other industrial effluents, which may pose a major problem when discarded into the environment without prior treatment [23].

Saraiva [27] points out that buttermilk resulting from the production of butter and whose composition is similar to that of skimmed milk, may also contribute to increased organic load in wastewater. Like all dairy processing plants, the company generates a warm, liquid effluent stream containing milk constituents and cleaning and sanitizing agents.

The organic pollutant content of dairy effluent is commonly expressed as the 5-day Biochemical Oxygen Demand (BOD5) or as Chemical Oxygen Demand (COD). One litre of whole milk is equivalent to approximately 110,000 mg BOD5 or 210,000 mg COD.

Concentrations of COD in dairy processing effluents vary widely, from 180 to 23,000 mg/L. Low values are associated with milk receipt operations and high values reflect the presence of whey from the production of cheese. A typical COD concentration for effluent from a dairy plant is about 4000 mg/L. This implies that 4% of the milk solids received into the plant is lost to the effluent stream, given that the COD of whole milk is 210,000 mg/L and that effluent COD loads have been estimated to be approximately 8.4 kg/m^3 milk intake [28].

The quantity of effluent discharged per year is 30,246 m^3/year. The organic loading of this wastewater averages about 18,800 ppm COD, 13,160 ppm BOD and 10,640 ppm TSS (Table 7).There is no industrial wastewater treatment facility and the wastewater is disposed into the city sewerage system. Company is not connected to a wastewater treatment plant and therefore discharges treated effluent directly to surface water. There is no industrial wastewater treatment facility and the wastewater is disposed into the city sewerage system.

Table 5: Water Consumption at dairy processing Miser Company.

Water consumption	Factory uses (m3/year)
Processing	2,880
Equipment and floor washing	20,160
Boiler feed and cooling water	6,840.00
Domestic use	7,200

Table 6: Sources of milk losses to the effluent stream at dairy processing Miser Company.

Process area	Source of milk loss
Milk receipt and storage	Poor drainage of tankers, Spills and leaks from hoses and pipes, Spills from storage tanks, Foaming, Cleaning operations.
Pasteurisation and ultra-heat treatment	Leaks, Recovery of downgraded product, Cleaning operations,
	Foaming, Deposits on surfaces of equipment.
Homogenisation	Leaks, Cleaning operations.
Separation and clarification	Foaming, Cleaning operations. Pipe leaks.
Market milk production	Leaks and foaming, Product washing, Cleaning operations,
	Overfilling, Poor drainage, Sludge removal from separators/clarifiers, Damaged milk packages, Cleaning of filling machinery.

Cheese making	Overfilling vats, Incomplete separation of whey from curds, Use of salt in cheese making, Spills and leaks, Cleaning operations.
Butter making	Va creation and use of salt, Cleaning operations.
Milk powder production	Spills during powder handling, Start-up and shut down processes, Plant malfunction, Stack losses, Cleaning of evaporators and driers, Bagging losses.
Source:**[20]**	

Table 7: Waste water Characteristics at dairy processing Miser Company.

Waste water Characteristics	Industrial wastewater(m^3/year)
BOD	13,160
COD	18,800
TSS	10,640

BOD (ppm): Biochemical Oxygen Demand (Part per million); COD (ppm): Chemical Oxygen Demand (Part per million); TSS (ppm): Total Solids.

Energy consumption

Around 80 % of a plants need of energy is met by the combustion of fossil fuels to generate steam and hot water. The other 20 % are met by electricity to run electrical motors, refrigeration, ventilation and lightening. The total energy consumption causes on the age and the scale of plant, on the automation level and the range of produced products. A typical range for energy consumption is 0.5-1.2 MJ/kg milk intake. Implementing CP strategies, the range can decrease to 0.3 MJ/kg milk intake. However, the consumption of different types of energy causes air pollution and greenhouse gas emissions. The energy consumed depends on the range of products being produced. Processes, which involve the concentration and drying of milk, whey or buttermilk, for example, are very energy intensive. The production of market milk at the other extreme involves only some heat treatment and packaging, and therefore requires considerably less energy. Table provides some indicative figures of specific energy consumption of different dairy products (Table 8).

Table 8: Specific energy consumption for various dairy products*.

Product	Electricity consumption (GJ/tonne product)	Fuel consumption (GJ/tonne product)
Market milk	0.2	0.46
Cheese	0.76	4.34
Milk powder	1.43	20.6
Butter	0.71	3.53
[29]		

CP opportunity assessment

CP opportunities were identified by means of an industrial or cleaner production audit. The audit findings were as follows:

- Different solid wastes stored haphazardly in open areas and roads, constituting a fire risk and impairing the general appearance of the premises.
- Considerable amounts of milk were wasted due to overflow during the filling of storage and service tanks.
- Milk leakages in the milk packaging and refrigeration units.
- Oils used in the car and truck maintenance facilities was drained to factory sewers, encouraging drain blockage and consequent development of foul odors.
- Excessive consumption of mazot in the boiler house, due to poorly tuned boilers. This also resulted in excessive air emissions (mainly smoke and carbon monoxide) being discharged from the boiler stacks.

Table 9: Summary of Cost Benefits.

Factory Unit	Action	Capital and Operation Costs (LE)	Yearly Savings (LE)	Payback Period (month)
All	Improve Housekeeping and Solid Waste Removal	13,000	120,000 (One of sale)	1
Milk Packaging and Storage	Rationalize Milk Packaging and Increase Milk Refrigeration Efficiency	26,500	39,600	8
White Cheese	Reuse Whey	0	2,000	Immediate
Boiler House	Upgrade Boiler and Restore Softening Unit	2,000	18,750	< 1
Garage	Collect Used Oil	500	2,500	< 3
Milk Receiving and Pasteurization	Milk Tank Level Controls	10,250	126,000	7
	Food Quality Valves	64,000		
Total		116,250	308,850	< 5

CP applications

During the audit stage, particular attention was paid to those improvements, which could be carried out at low or no cost to the factory. These were given high priority, as they are easy to implement and often entail significant savings. The measures, which have already been implemented by the factory or under implementation through the Cleaner Production Demonstration Projects of the SEAM project, are briefly outlined below.

Low cost" Housekeeping" Improvements

Improve housekeeping

In-plant housekeeping of factory units and buildings was improved, factory drainage, sewers, and manholes were maintained and upgraded to eliminate blockage and overflow problems. In-plant roadways were paved and signposts added to allow for better traffic flow of factory vehicles. Unattended areas were planted with trees and greened. Overall, the factory has improved its image and cleanliness.

Implementation Cost: LE 10,000.

Used garage oil: collection for resale

Pollution loads from the garage and workshops constitute the highest level of suspended solids (9,14 ppm), and the only source of mineral oil and grease (1,245 ppm) generated in the factory. Oil, grease and lubricants are now collected instead of being disposed to the sewer, with the following benefits:

- Approximately 0.75 tons of oil are accumulated monthly and sold at LE 275 per ton.
- Reducing the strength of wastewater,
- Improving the cleanliness of the garage and workshops,
- The prevention of serious blockage of sewers and overflow (as oil and grease tend to solidify milk products if mixed in sewers).

Implementation Cost: LE 500

Annual Savings: LE 2,500

Solid waste: collection and sale

Solid wastes generated by the factory were initially segregated and then either disposed or sold:

- Garbage and packaging wastes are trucked out daily and disposed a
- Solid wastes such as scrap iron and metals objects are sold in auctions or to special scrap dealers.

This action has achieved an efficient removal of wastes from the site, and improved cleanliness of factory premises. LE 120,000 was generated as a, one off, sum from the sale of solid wastes.

Implementation Cost: LE 3,000

Savings: LE 120,000

Water and energy conservation

Boiler tune-up and upgrade

The ratio of air mazot was optimized to increase the efficiency of boilers, hence reducing mazot consumption and gas emissions. Benefits of this measure includes:

- Mazot consumption has reduced by 60 tons/year, saving LE 10,740.
- Solar consumption has been reduced by 12 tons/year, saving LE 4,980.
- Electricity consumption has been reduced by 12,775 kWh/year, saving LE 2,500.

Restoration of softening unit

The softening unit was restored to prevent the scaling of the boiler by chemical treatment of the feed water. As a result of implementing this improvement, tuning and upgrading the boilers, steam generation from 1m^3 of water has increased from 1 ton to 1.16 tons, corresponding to a 16% increase in boiler efficiency.

Implementation Cost: LE 2,000

Annual Savings: LE 18,750

Reuse and recycling

Increase Refrigeration Efficiency and Rationalize Milk Packaging

Raw milk storage units and the refrigeration room of the packaged milk products were upgraded to prevent spoilage and loss. This was achieved through investment in a refrigeration system, which permitted temperature to be fully controlled. The benefits from this intervention include:

- Increased production capacity.
- Improved process efficiency.
- Improved quality control.
- Reduced reject rates of the final product.

The packaging unit was relocated from a restricted area to be adjacent to the refrigeration facility thus preventing handling losses. This has reduced milk losses by 3.3 tons/month, corresponding tp monthly savings of LE3,330

Implementation Cost: LE 26,500

Annual Savings: LE 39,600

Whey reuse in white cheese manufacturing

4.4m^3 of permeate with a high lactose concentration (4.5%) is generated as a byproduct from ultra-filtration in this process. Originally, this was disposed directly to the sewer. The factory now reuse 50% of this in the cheese packing stage, in place of fresh water. This has resulted in a 50% drop in organic load generated from white cheese unit from 5,800ppm to about 3,000ppm. Almost 2,200m^3 of water are saved on an annual basis.

Implementation Cost: None

Annual Savings: LE 2,000

Installation of new equipment

Total loses from factory in both raw milk and products were shown to be 0.80 tons/day. The receiving and pasteurization processes were the greatest sources of wastage, with milk losses of up to 0.7 tons/day, valued at LE 252,000 per year.

The problem: Raw milk coming into the factory is transferred directly from delivery vehicles into the storage tanks. As the were no level gauges or controls on the tanks, overfilling and spillage frequently occurred.

The solution: installation of level controls

Milk storage tanks were equipped with level sensors and stopcocks to prevent overflow particularly during the receiving stage. This type of sensor was selected rather than infra-red sensors, as foaming of the milk as it is transferred can result in inaccurate readings and subsequent overflow.

Implementation Cost: LE 10,250

The problem: Leakages of milk from valves throughout the system were common, resulting in milk loss and an increased organic load of the final effluent.

The solution: installation of control valves

The installation of food quality, stainless steel control valves were installed throughout the factory where required, including the milk receiving, storage and pasteurization areas. Forty valves were required.

Implementation Cost: LE 64,000

The implementation of the above improvements has resulted in daily savings of 350 kilograms of milk. A total of 126 tons of milk are recovered annually resulting in savings of LE 126,000 per year. Additional benefits include:

- Reduced pollution loads,
- The elimination of floor spills,
- Improved hygiene and safety.

Economics

Throughout industry, pollution prevention and environmental protection measures can offer real financial benefits in terms of:

- Reduced raw materials consumption;
- Waste minimization and
- Reuse or recycling of in-plant materials.

Implementing these measures will also result in reduced environmental pollution and Movement towards discharge consent limits. The total capital and operation costs invested in the cleaner production measures at the Mansoura factory amounts to LE 116,250. This has produced total savings of over LE 308,850 with an average payback period of around 4 months (Table 9).

Benefits and achievements

• Recovery solutions and better quality control of milk products and byproducts has recovered 166 tons of milk/year (2.3%), which was previously wasted.

- \Water consumption has dropped by 6%.
- Mazot consumption has decreased by 10%.
- Solar consumption has decreased by 5%.
- Electricity consumption has been reduced by 9%.

Conclusions

CP is proven to be an efficient technique in improving material consumption, reducing energy utilization, and decreasing emission levels of pollutants. CP also encourages positive, defensive action and encourages a holistic view of resources, economy, production, and the environment. Case studies showed that CP application changed the quality and quantity of raw materials, consumed energy, production, generated wastes, and working environment.

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